REVEGETATION OF GOPHER MOUNDS ON ASPEN RANGE IN UTAH

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ABSTRACT.— The colonization of the pocket-gopher (*Thomomys talpoides*) mounds by annual and perennial species of the understory of aspen woodland was observed over a four-year period. New and old gopher mounds exist as a mosaic of sites in one of three surface conditions: bare, dominated by annuals with a few seedlings of perennials, and dominated by perennials with annuals in peripheral areas. The regular creation of these new sites for plant colonization appears to favor the maintenance of aggressive perennials at high densities in the understory vegetation.

On mountain rangeland in the western United States, foraging and soil-displacement activities of pocket gophers (*Thomomys talpoides*) have important effects on vegetation (Julander et al., 1969; Turner, 1969). The mounds and casts created by runway and cavity excavation present a new surface for plant colonization—seedbed conditions that may favor the establishment of particular species (Laycock, 1958). The purpose of this study was to describe the colonization of gopher mounds over a four-year period (1969 through 1972) on aspen (*Populus tremuloides* Michx.) range in Utah.

The aspen woodland of the study area (Fig. 1) occupies approximately 2 ha on a 19-degree south-facing slope at an elevation of 1900 m in Tony Grove Canyon on the Cache National Forest in northern Utah. Density of aspen (DBH greater than 5 cm) averages 2900/ha, and there is a dense understory vegetation of shrubs and annual and perennial forbs and grasses. Florez (1971) described the soil, climate, and vegetation of the site.

METHODS

In early July 1968, 80 new gopher mounds were identified and numbered. In July 1969, the 50 mounds with the lowest assigned numbers and no previously established perennials emerging from them were designated for study. Percentage canopy cover of individual colonizing species was estimated visually in early July and early September of each year.

To determine the density, frequency, and distribution of new mounds each year, two belt transects, each 128 m long and consisting of 128 quadrats (each 1 m^2), were established 30 m apart near midslope where mound counts had indicated high mound-building activity. The transects were examined in early July of each year for new mounds. A mound was counted if any part of it was found within a quadrat. The distribution of mounds was estimated by use of variance-mean ratios (Greig-Smith 1964). In mid-June and mid-July of 1970, plant species in each of the quadrats of the transects

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Fig. 1. The aspen woodland study area.

were noted. Dimensions and other characteristics of mounds were taken from 43 new mounds found in the transects in 1969. Frequency percentages of species on mounds over the four years of colonization were taken from the 50 mounds selected in 1969; quadrat frequencies were based on the transect data collected in 1970.

Soil samples of equal volume were taken from five new mounds and adjacent, undisturbed topsoil in late September of each year for standard fertility analysis—texture, pH, conductivity (total salts), organic matter, P, K, Ca, and NO_3-N. Subsamples from these collections were used to determine seed content by sieving and flotation on water. Additional collections of mound and adjacent topsoil were used in pot culture of two common annual (*Collomia linearis*, *Veronica biloba*) and two perennial (*Rudbeckia occidentalis*, *Senecio serra*) species with high densities in the study area. The purpose was to determine whether the soils affected plant growth. There were six 20-liter containers per species and four plants per container. After two months' growth in the greenhouse, shoots were harvested for oven-dry weight determinations. The statistical significance of differences was evaluated at the 5 percent level.

Results

Plants.— Based on quadrat frequency percentages, the most prevalent species were *Nemophila breviflora* and *Polygonum douglasii* among the annuals and *Bromus carinatus* and *Rudbeckia occidentalis* among the perennials (Table 1). Seed dispersal occurs

TABLE 1. Species frequencies in the quadrats of belt transects in 1970 and on gopher mounds during four years of colonization.

Species	Frequency (%) Quadrat	Mound
Annual		
Chenopodium album L.	40	26
Collomia linearis Nutt.	43	38
Galium bifolium S. Wats.	34	46
Nemophila breviflora A. Gray	87	82
Polygonum douglasii Greene	68	56
Veronica biloba L.	57	64
Perennial		
Achillea millefolium L.	15	12
Agastache urticifolia (Benth.) Kuntze	13	18
Agropyron trachycaulum (Link) Malte	42	52
Bromus carinatus Hook. & Arn.	83	74
Delphinium occidentale (S. Wats.) S. Wats.	19	20
Elymus glaucus Buckl.	21	34
Phacelia utahensis J. Voss	30	22
Rudbeckia occidentalis Nutt.	95	82
Senecio serra Hook.	40	56
Stellaria jamesiana Torr.	18	34

among the annuals from late June and early July (*N. breviflora*, *V. biloba*) through September (*P. douglasii*, *Chenopodium album*), and toward the end of summer in most of the perennials. Seeds of the species listed in Table 1 are gravity dispersed, except for *S. serra* (wind dispersed) and *Galium bifolium* (adhesive).

GOPHER MOUNDS.— The outline of mounds varied from nearly circular to elliptic, with mean dimensions of 46 by 38 by 9 cm depth. Density of mounds per m^2 ranged from 0.06 to 0.22 and frequency percentages from 5 to 17 in the transects over the four-year period (Table 2). Variance-mean ratios were significantly greater than unity in four samples, indicating clustered distributions, and did not differ significantly in three samples, indicating random distributions (Greig-Smith 1964). Mound clusters were observed in some locations (Fig. 2), usually in midsummer. New mounds occurred in

TABLE 2. Density, frequency, and variance-mean distribution ratios of new mounds in the quadrats of belt transects.

Year	Transect	Density (m^2)	Frequency (%)	Variance-mean ratio
1969	1	0.17	13	1.41*
	2	.16	12	1.44*
1970	1	.06	5	1.50*
	2	.15	12	1.13
1971	1	.12	10	1.08
	2	.22	17	1.27*
1972	1	.09	8	1.11
	2	.19	16	1.05

*Differs significantly from unity.

Fig. 2. Clustered mounds were observed in some locations, usually in midsummer (30 cm ruler in foreground).

different quadrats from year to year, and 40 percent of the quadrats were occupied one or more times over the four-year period.

Soil.— The soil of new mounds was higher in conductivity and lower in NO_3-N than was adjacent topsoil (Table 3). Since the soil of the mounds had been reworked by gopher action, it was uncompacted and friable as compared with the undisturbed topsoil. However, these chemical and physical differences did not affect the dry weight of shoots of annuals (*C. linearis*, *V. biloba*) or perennials (*R. occidentalis*, *S. serra*) after two months' growth in the greenhouse.

Seeds.— No seeds were found in new mounds constructed before seed dispersal began; equivalent volumes of adjacent topsoil contained a mean of 36 seeds from nine species. Their weathered appearance suggested that most of these seeds were ungerminated from previous years and probably were not viable. By the end of September when seed dispersal had ceased, the mean count per mound was 37, significantly higher than the 23-seed mean for equivalent columns of adjacent topsoil. Mounds appeared to act as catchment areas; dispersed seeds were often buried in the loose mound soil. Four species (*N. breviflora*, *P. douglasii*, *B. carinatus*, and *R. occidentalis*) accounted for 64 percent of all seeds recovered.

Colonization.— By October of the first year, 8 percent of the new mounds had been colonized by seedlings of three species: *Agastache urticifolia*, *R. occidentalis*, and *V. biloba*. By early summer of the second year, 94 percent of the mounds had been colonized by seedlings; and 100 percent colonization was attained by late spring of the third year. For species occurring on both quadrats and mounds, quadrat frequencies (greater than 10 percent) in transects in the summer of 1970 and frequencies on 50 mounds over the four-year period are given in Table 1. Photographs of representative mounds in various stages of colonization are shown in Figures 3 through 6. Of the 8 annual and 14 perennial species that colonized mounds, *N. breviflora* was the best represented annual and *R. occidentalis* the most prevalent perennial. The correlation coefficients between mound and quadrat frequencies were significant for both annuals

Table 3. Results of soil analysis from gopher mounds and adjacent undisturbed topsoil.

Factor	Mound soil	Undisturbed topsoil
Texture	Silt loam	Silt loam
pH	6.2	6.3
Conductivity (mmhos/cm)*	.33	.25
Organic matter (%)	4.7	4.9
P (ppm)	56	65
K (ppm)	466	480
Ca	0	0
NO_3-N (ppm)*	7.2	8.0

*Results differ significantly.

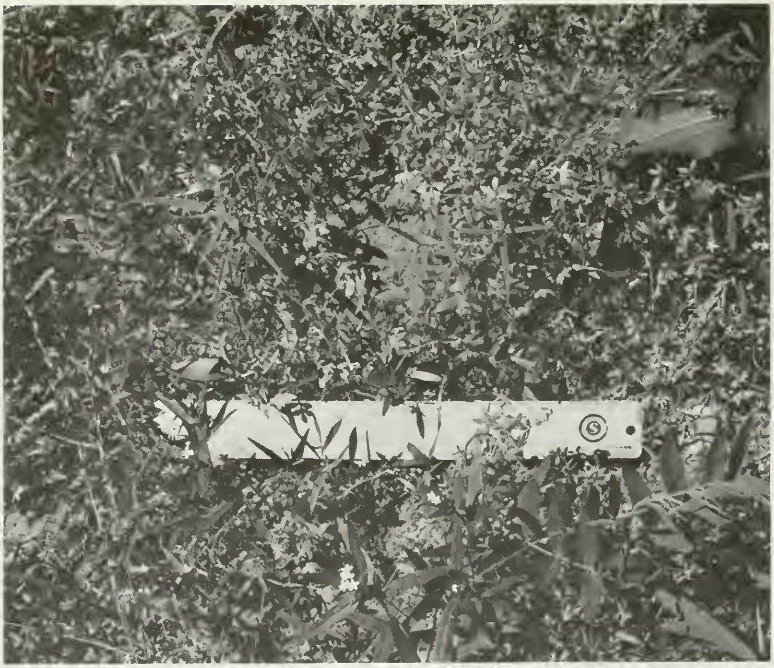

Fig. 3. First-year colonization by *C. linearis*, *N. breviflora*, and *S. jamesiana*.

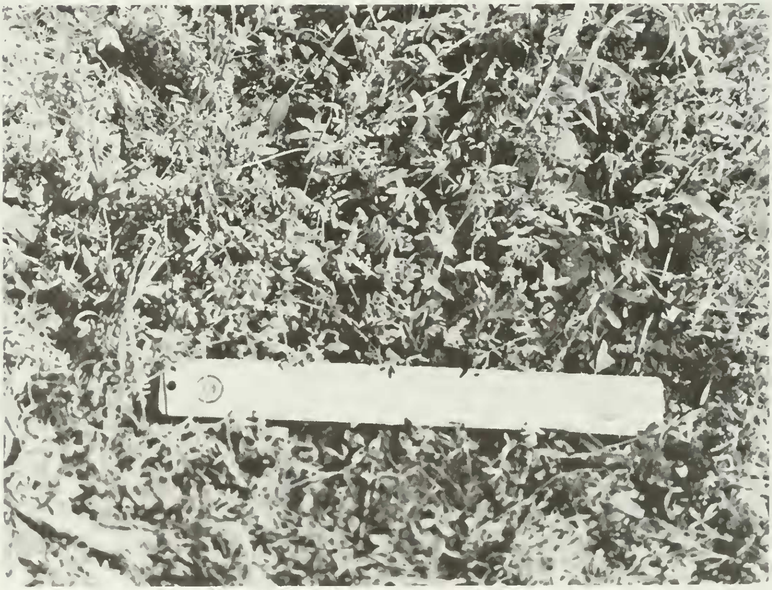

Fig. 4. Second-year colonization by *N. breviflora*.

Fig. 5. Third-year colonization by *R. occidentalis.*

Fig. 6. Fourth-year colonization by *S. serra.*

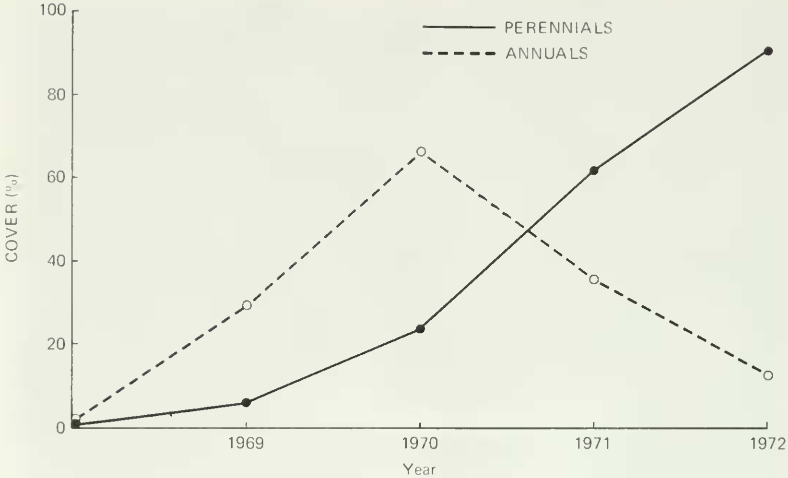

Fig. 7. Percentage of annual and perennial species cover during four years of colonization.

(r = 0.85) and perennials (r = 0.94). This reflects gravity dispersal of seeds to the mounds from adjacent plants, with higher probabilities for colonization by the more widely distributed species in the area.

The revegetation of mounds progressed from an initial dominance by annuals to dominance by perennials—a displacement largely completed within the four-year period (Fig. 7). The annuals reached maximum cover values in the second year and declined thereafter, while cover by perennials rose steadily through the period.

Conclusions

Soil disturbance by gophers creates small and constantly shifting new sites for colonization by plant species in the vicinity. Because new mounds appeared in 40 percent of the quadrats in the sample transects over the four-year period, it seems probable that a large portion of the woodland soil is overturned and laid bare over longer periods. Gopher mounds thus represent a mosaic of sites, constantly shifting in time and space, that individually exist in one of three soil-surface conditions—bare, invaded and dominated by annuals with a few seedlings of perennials, and dominated by perennials with a few persistent annuals in peripheral areas.

In aspen vegetation in Wyoming, Laycock (1958) found that 95 percent of all individual plants growing on gopher mounds during one summer were annuals. He concluded that the persistence and spread of annuals in the community were related to the level of mound-building activity. The constant renewal of bare surfaces keeps the aspen understory open to annuals that otherwise might be eliminated or persist only in low densities.

The constant renewal of bare surfaces also appears to work to the advantage of aggressive perennials, such as *R. occidentalis*, which is known to be an increaser species on aspen range. *Rudbeckia* produces an abundance of seed of high and rapid germinability over a wide temperature range, and there is vigorous seedling growth with relatively low mortality (Florez 1971; Florez and McDonough 1973). *Rudbeckia* appears, along with *B. carinatus*, to take advantage of gopher mounds to increase its importance in the aspen understory vegetation. However, the presence of aggressive species does not negate the effect of gopher activity in maintaining diversity in the species composition of the understory vegetation.

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